Session III: Power & Energy Architecture for NZE

United States Army Corps of Engineers
Net-Zero Energy (NZE) Installation & Deployed Bases 2-Day Workshop

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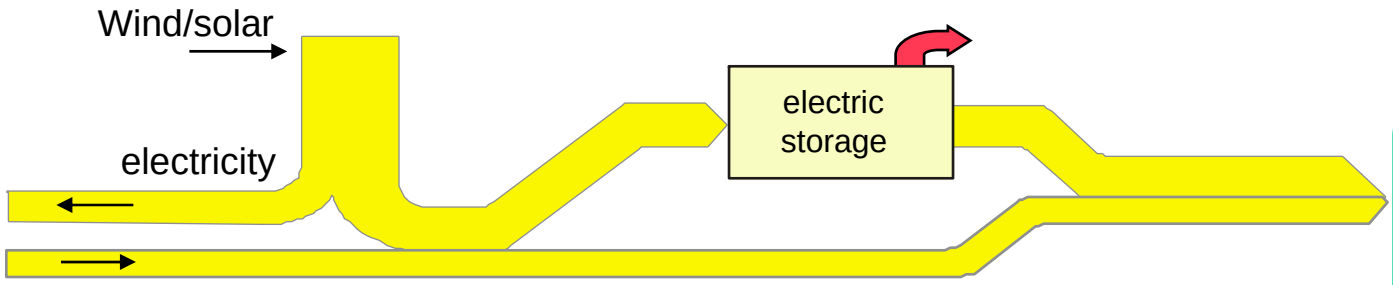
Colorado Springs, CO
3 February, 2009

Power & Energy Architecture Issues

- Full spectrum of applications from whole campus to forward operating bases.
- Loads from ultra low (residential) to very high (maintenance/industrial).
- Creation of adaptable and modular building blocks for both thermal and electrical architectures
- Optimize the use of onsite renewables.

electricity/ NZE systems

NZE constraint:
kw in= kw out

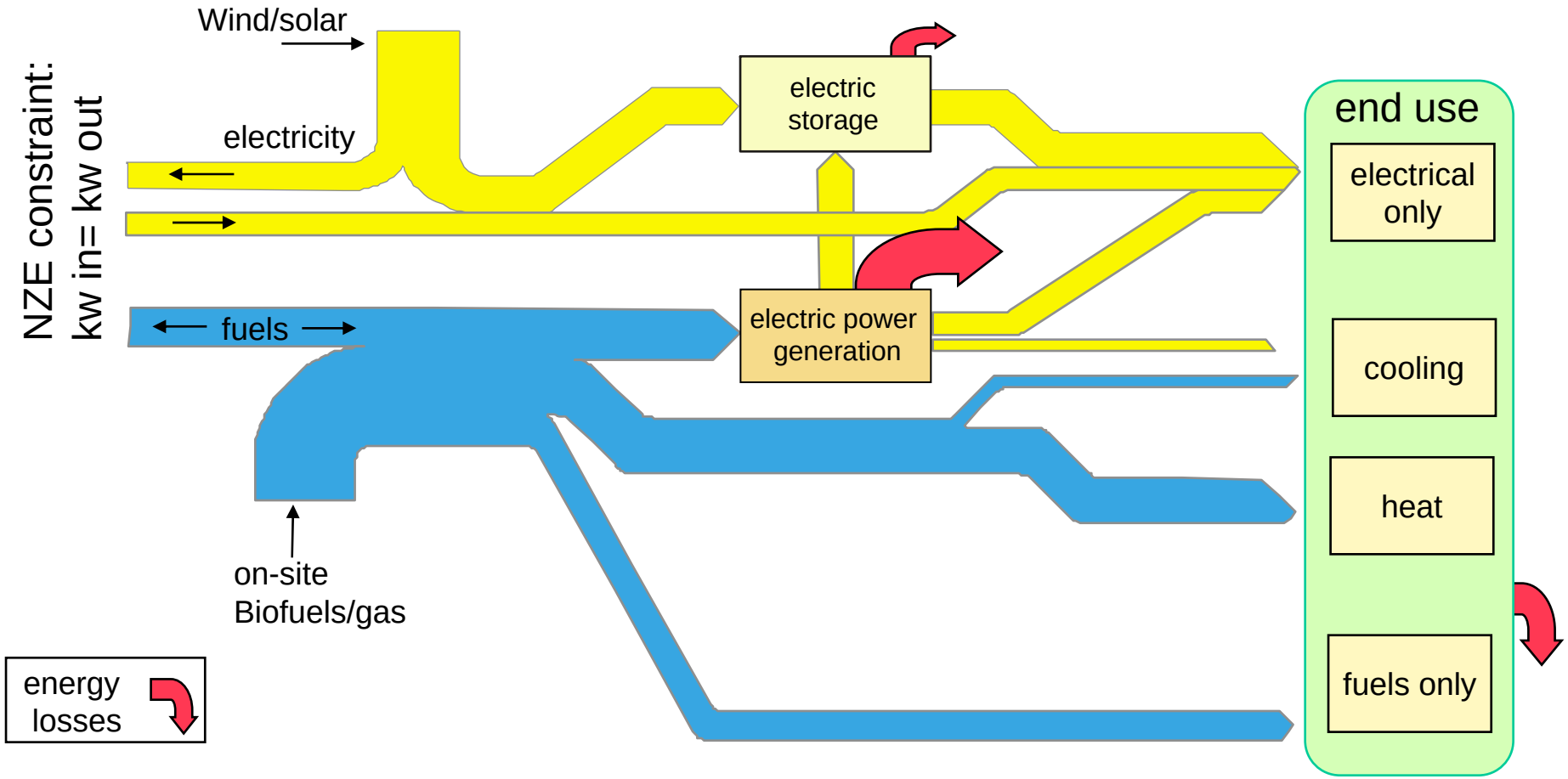


- NZE constraint: purchased electricity = sold electricity
- Constraints: footprint and/or available photons/wind

Need for fuel and/or other forms of energy

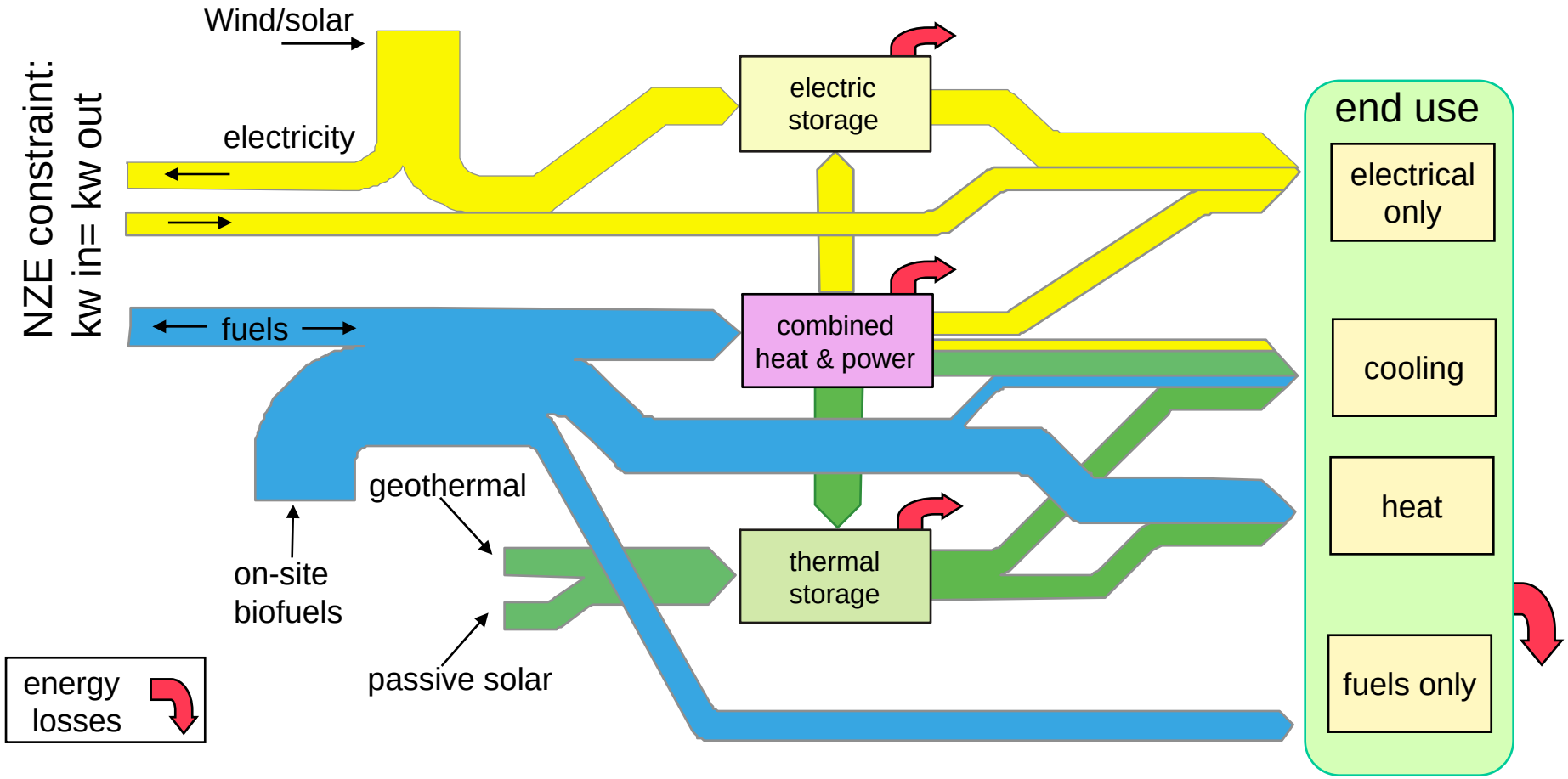
energy losses

electricity and fuel can provide for NZE



thermal management is key

basic energy architecture for all systems



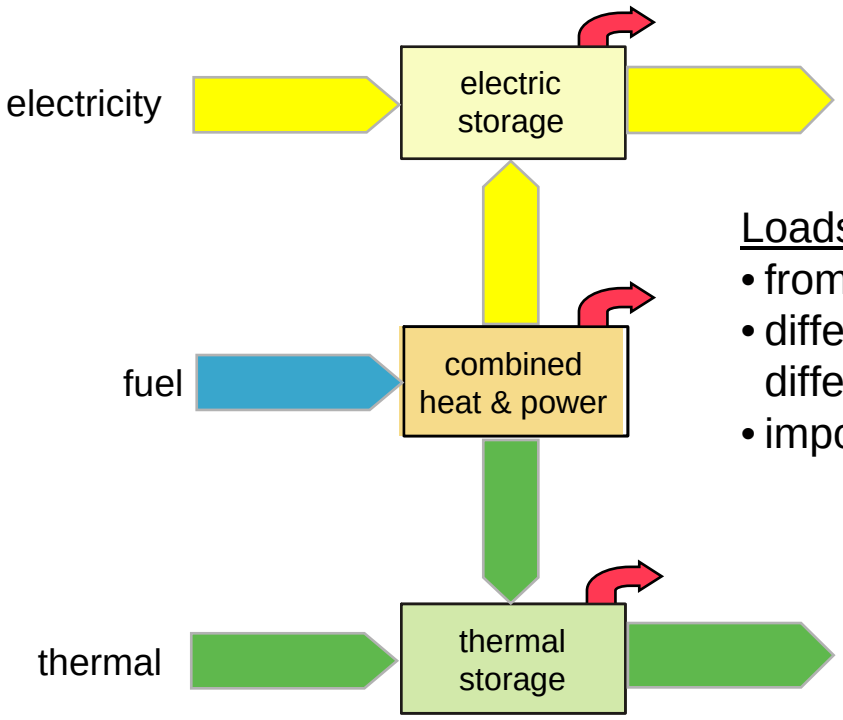
Key components of a Power & Energy Architecture

- Need for a modular model
- Sizing of key elements based on input limits & load needs

Limits:
- external electricity
- renewables (footprint available photons/wind)

Limits:
- external fuels
- biofuels (waste streams & processing rates)

Limits:
- available solar energy
- geothermal (permanent vs. temporary facilities)



Loads:
- from ultra low to very high
- different energy forms for different loads
- importance of loads to mission

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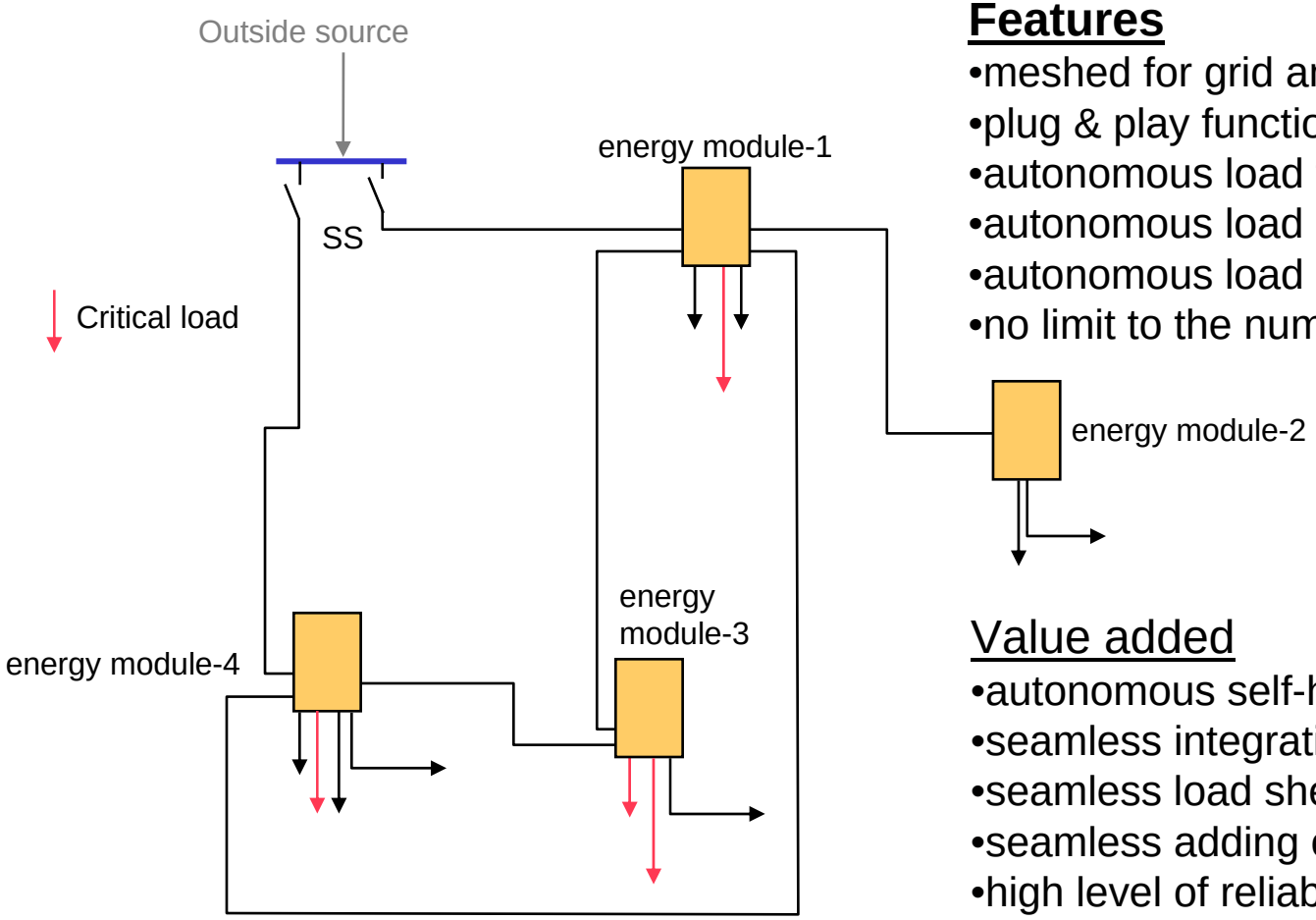
Meshed Microgrid (building, site, forward operating base…)



Features

- meshed for grid and island operation
- plug & play functionality
- autonomous load tracking
- autonomous load shedding
- autonomous load sharing between units
- no limit to the number modules

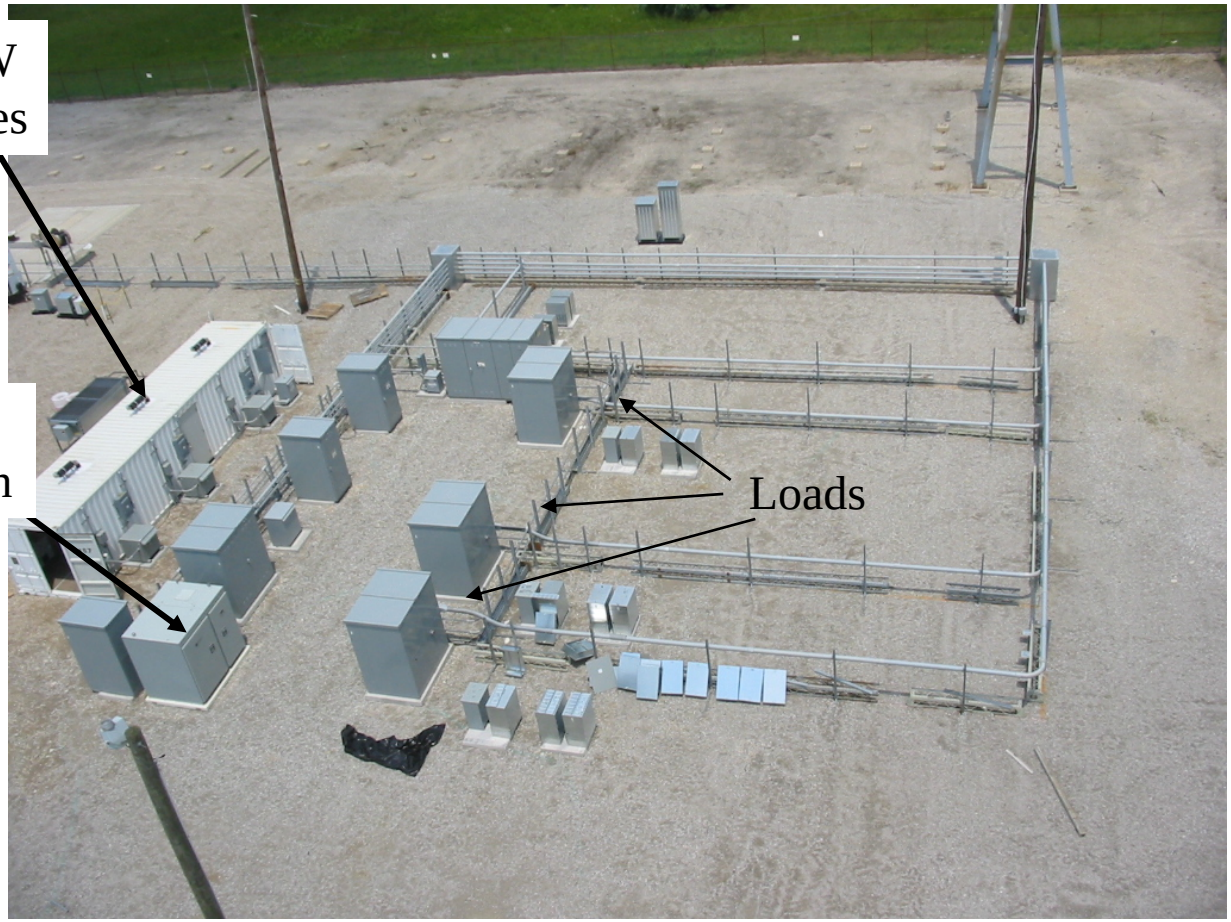
Value added

- autonomous self-healing
- seamless integration of renewables
- seamless load shedding
- seamless adding or removal of modules
- high level of reliability n+1
- networking reduces fuel needs 50%

AEP/CERTS Microgrid test site

60 kW Sources

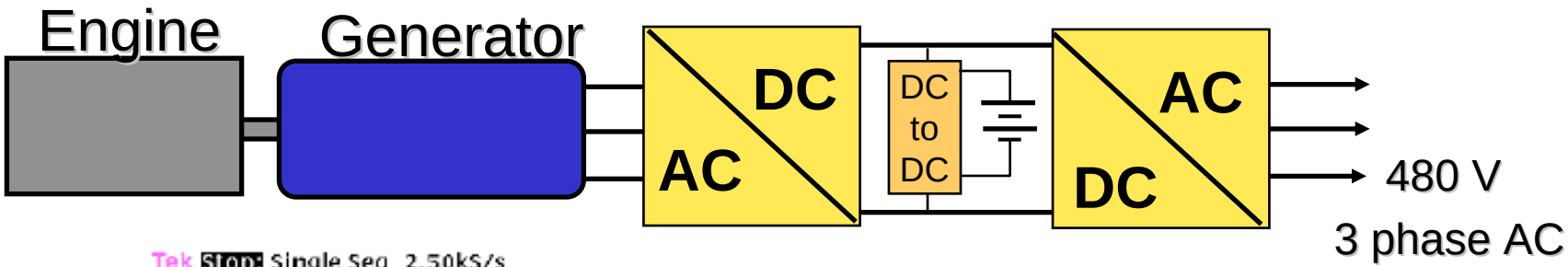
Static Switch

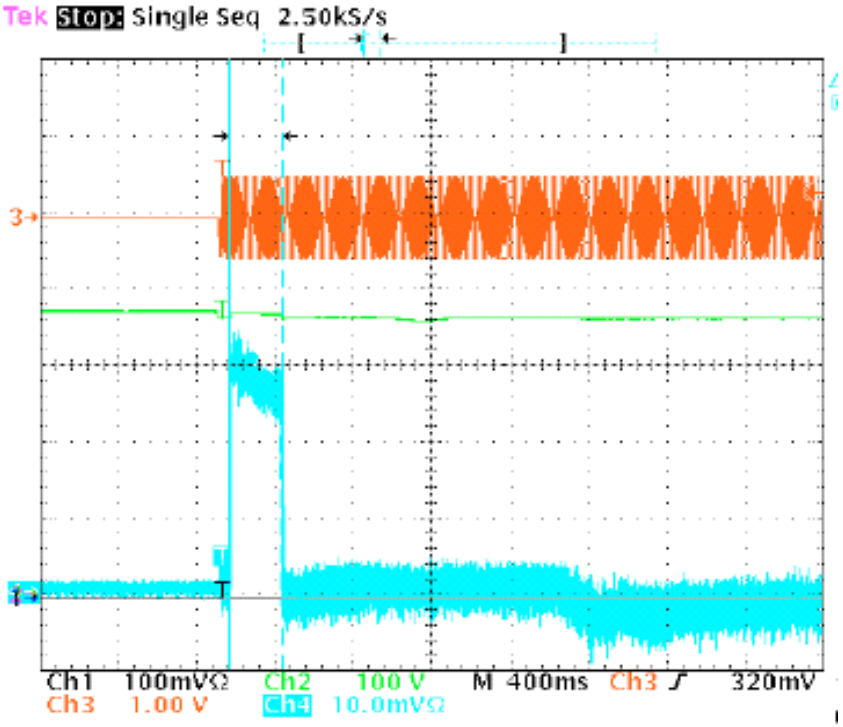


Concepts were fully tested at AEP/CERTS test site:

http://certs.lbl.gov/certs-derkey-mgtb.html

commercial microgrid source



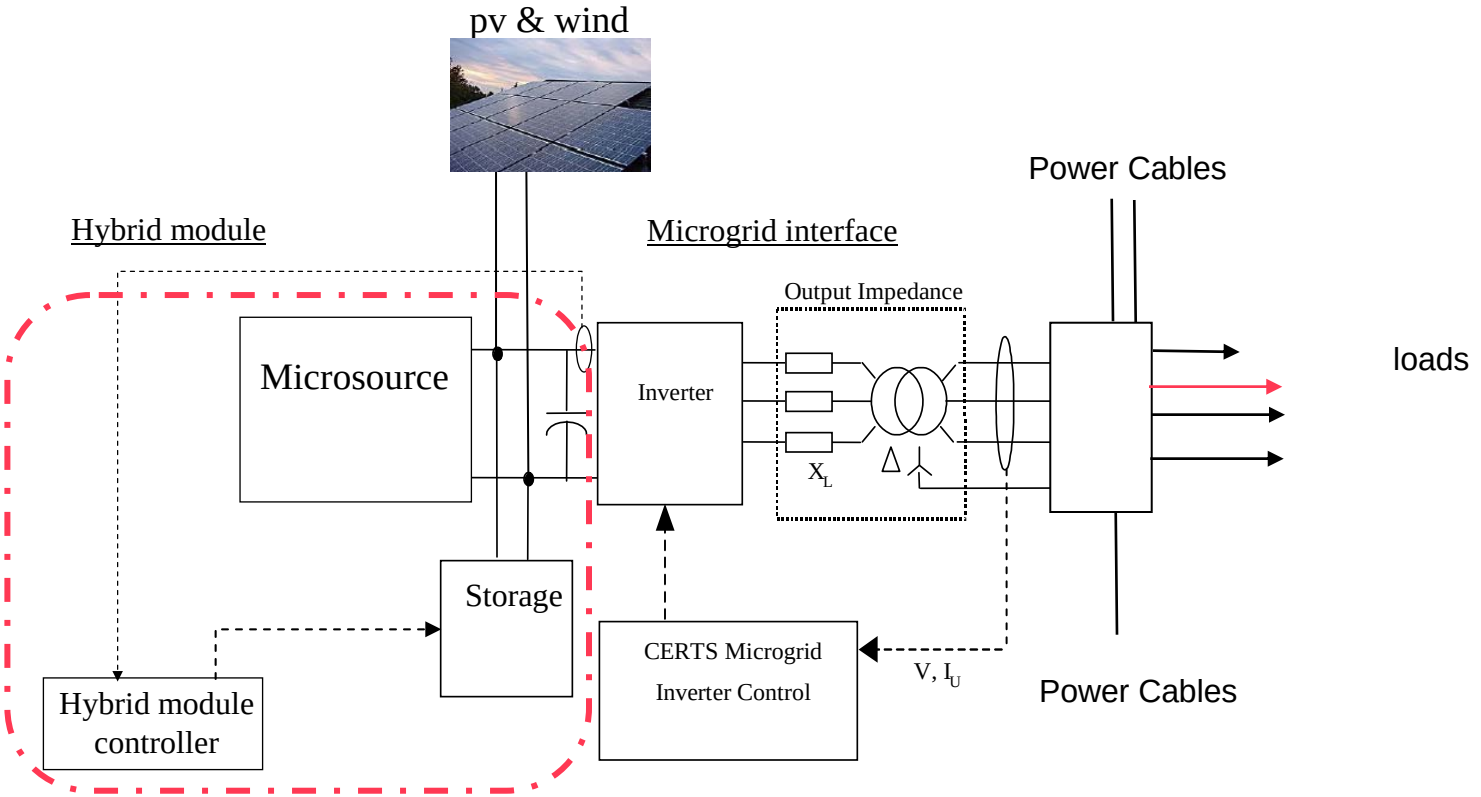


AC current

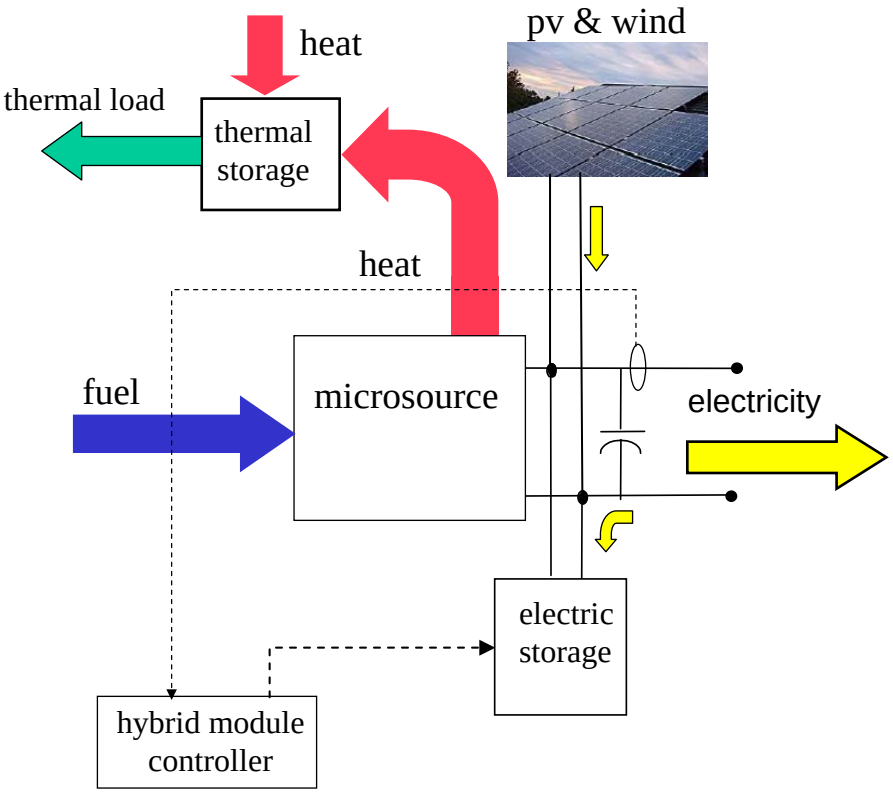
Dc voltage

Injected storage current

Hybrid Power/Energy Module



Hybrid Energy Module



Trade-offs in use and rating

Energy sources

- Electrical & thermal
- fuels/bio-fuels

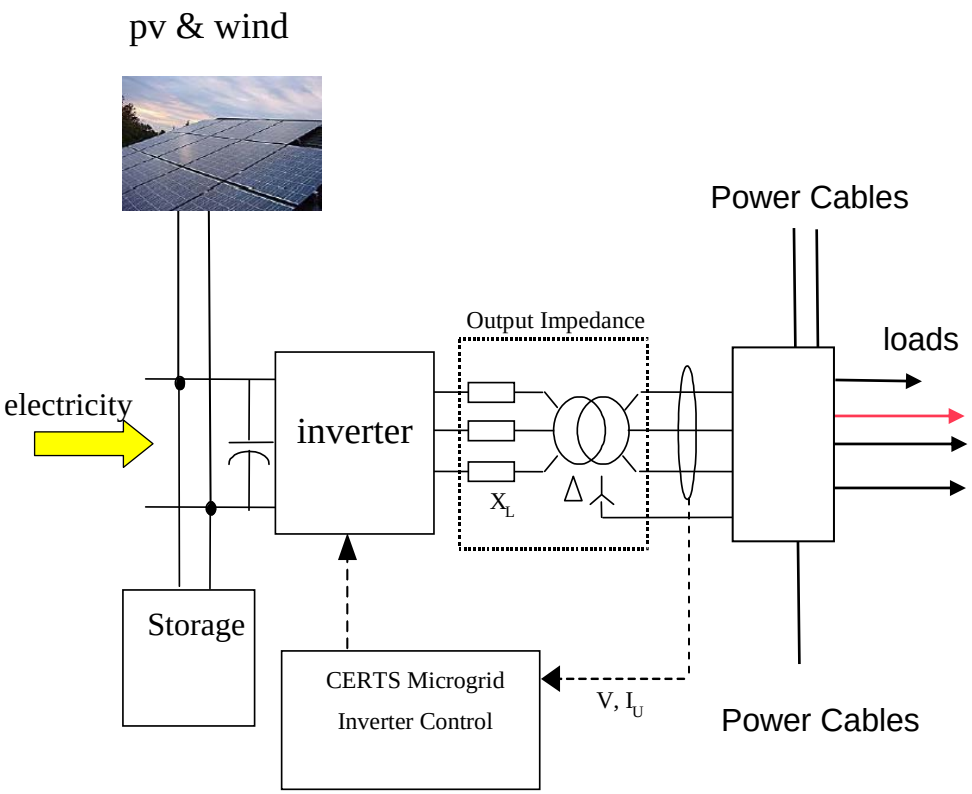
Loads & storage

- electrical
- thermal

Operation of the microsource

- Microsource either operates at its *optimal efficiency* or is off.
- Operates when thermal and/or electrical storage is below its threshold energy level.
- Storage is sized to minimize the operation of the microsource related the *available reneables.*

Microgrid inverter interface



CERTS Microgrid controller

- Autonomous (No central controller)
- Plug & Play model (promotes CHP & reduces site engineering)
- Peer-to-Peer model (no master element)
- Scalable components

Electrical system issues

- Each DER unit is a voltage source.
- Multi-unit stability is insured through voltage vs. reactive power control.
- Communication between components is through *frequency*.

  DER output control uses power vs. *frequency* droop.

  Intelligent load shedding on low *frequency.*

  Automatic re-synchronizing using *frequency* difference between the island and Utility network.

Modular Architecture Issues

Electrical

- integration and control of storage and pv in the hybrid energy module
- load control & building electrical infrastructure issues

CHP

- efficient use of electrical and thermal sources
- serving different thermal loads (heating and cooling)
- influence of electrical and thermal storage

Biofuels

- feasible on-site biofuels/gas
- available energy relative to waste streams & process rates
- modular issues

Thermal

- heating and cooling issues
- storage and modular architecture issues
- integration of passive solar, geothermal and CHP

Modular Architecture Issues

Electrical Prof. Tom Jahns University of Wisconsin

- integration and control of storage and pv in the hybrid energy module
- load control & building electrical infrastructure issues

CHP Clifford Haefke Midwest CHP Application Center

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Biofuels Chris Zygarlicke Energy/Environmental Research Center

- feasible on-site biofuel/gas
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Thermal Dr. Stephan Richter GEF Ingenieur AG

- heating and cooling issues
- storage and modular architecture issues
- integration of passive solar, geothermal and CHP